CHAPTER III

CROP TEMPERATURE OF SORGHUM, CORN AND SOYBEANS AS INFLUENCED BY IRRIGATION TREATMENT

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ABSTRACT

When moisture supply to plants becomes limiting, transpiration rate decreases and the plant temperature increases. This phenomenon of temperature increase can be used to signal the need for irrigation. In the study reported here we attempted: 1) to determine the effect of irrigation on the temperature of corn (<u>Zea</u> <u>mays</u> L.), grain sorghum (<u>Sorghum</u> <u>bicolor</u> L. Moench) and soybean (<u>Glycine</u> <u>max</u> L.) crops and 2) to test whether a predetermined crop temperature can be used to indicate when to irrigate.

The crops were grown in replicated plots that permitted four different degrees of water stress to be achieved. In each plot canopy temperature was measured at mid-day with an IR thermoemter. Air temperature 5-10 cm above the canopy top was measured with thermocouples.

Rainfall was adequate so none of the crops showed any evidence of moisture stress until after August 7, 1978. After that date, non-irrigated corn and soybeans were just slightly warmer (0.2 to 1.5 C) than were irrigated plants suggesting that only a very moderate level of water stress was achieved during the season. No signs of water stress were observed in non-irrigated sorghum during the season. In general, during mid-day periods, irrigated soybeans were 1 to 3 C cooler than were irrigated corn or sorghum. This suggests that soybeans have a greater transpiration rate or a more effective mechanism for transfering sensible

heat from the plant to the air than do either of the other crops studied.

INTRODUCTION

The crop temperature, T_c, integrates all variables which affect the transpiration rate and the energy transfer between the plant and the ambient air. The plant temperature may signal the occurrence and even the severity of moisture stress (Hiler and Clark, 1971; Clark and Hiler, 1973). Studies have shown that plant temperatures of water stressed plants are higher than those of non-stressed plants (Mayer, 1970; Miller et al., 1971; Karschen and Pinchas, 1971; Bartholic, et al., 1972).

The temperature of vegetation may depend on the particular type of vegetation or crop (Lange, 1959). For example, Heilman et al. (1976) found that soybeans (*Glycine max* L.) were 2-3 C cooler than sorghum (*Sorghum bicolor* L. Moench) under similar climatic and moisture conditions. Blad and Rosenberg (1976) observed different temperatures of alfalfa (*Medicago sativa* L.), wheat (*Triticum aestivum* L.), corn (*Zea mays* L.) and pasture under similar climatic conditions.

The temperature difference between the plant and the air may also be of interest as an indicator of plant stress or as a guide to irrigation scheduling. As plant water stress increases, T_c increases relative to air temperature, T_a. Palmer (1967) found that, when amply watered, the temperature of cotton (*Gossypium hirsutum* L.) was 1 C cooler than T_a. Under non-irrigated conditions the crop was 2 to 4 C warmer than T_a. A similar response for sorghum was reported by Ehler and van Bavel (1967) and van Bavel and

Ehrler (1968). Ehrler (1973) and Ehler et al. (1978) found that the T_c-T_a differences were measurable and predictable and, thus, might be used to schedule irrigations. They did state, however, that T_c-T_a may be a reliable indicator only in sunny climates.

Aston and van Bavel (1972) stated that the onset of soil water deficit can be detected by comparing the canopy temperature of a stressed plot with the temperature of a well-watered plot. Ritchie (1977) suggested the use of the temperature difference between stressed and non-stressed vegetation as a way of detecting soil moisture deficits. Nixon et al. (1973) did caution, however, that using the average canopy temperature elevation of water-stressed plants above non-stressed plants may not be strictly valid because of the temperature variations that occur across a field.

In view of the above we undertook a study, the objectives of which were: 1) to examine the crop temperature responses of corn, grain sorghum and soybeans to different irrigation treatments and 2) to evaluate the use of a predetermined crop temperature level as an indication of when to irrigate.

MATERIALS AND METHODS

The experiment was conducted at the University of Nebraska Agricultural Meteorology Laboratory at Mead (41° 09' N; 96° 30' W; 354 m above MSL). Corn, sorghum and soybeans were planted in 0.5 m rows in 6x20 m plots. Each plot was replicated. Soil in the experimental field at Mead is a Sharpsburg silty clay loam. Four different irrigation treatments were planned but, due to abundant rainfall, only three treatments were possible. These

were: a) well-watered, b) dryland and c) irrigation when the temperature difference between the well-watered plot and the stressed plot reach 1 C. This is called the 1SWW (stressed minus well-watered) treatment.

Because of limitations in the irrigation system it was necessary to irrigate all 1 SMW plots when one of them become 1 C warmer than the coresponding well-watered plot. Crop temperatures were measured daily between 1200 and 1300 hr solar time with a Barnes IT-3 IR thermometer. Measurements were made in each plot from atop a 2 m ladder. Three readings were averaged to give the crop temperature. Air temperature measurements were made 5 to 10 cm above the canopy in four different plots for each of the three crops. Ground squirrel damage and moisture problems in the signal cables and junction boxes, which were not rectified until late in the study, minimized the utility of the air temperature data.

RESULTS AND DISCUSSION

Sorghum crop temperatures are presented in Fig. 1. There was no evidence of water stress in any of the sorghum plots during 1978. Temperatures of the well-watered sorghum plot were never consistently cooler than that of the plot that received no supplemental irrigation. Irrigation of the 1SMW plot on August 15 caused no detectable cooling of that plot relative to the dryland plot. The 1SMW and the dryland plot had received the same amount of water prior to that date. The evidence is, therefore, rather conclusive that, in 1978, natural rainfall and stored soil moisture were adequate to prevent any water

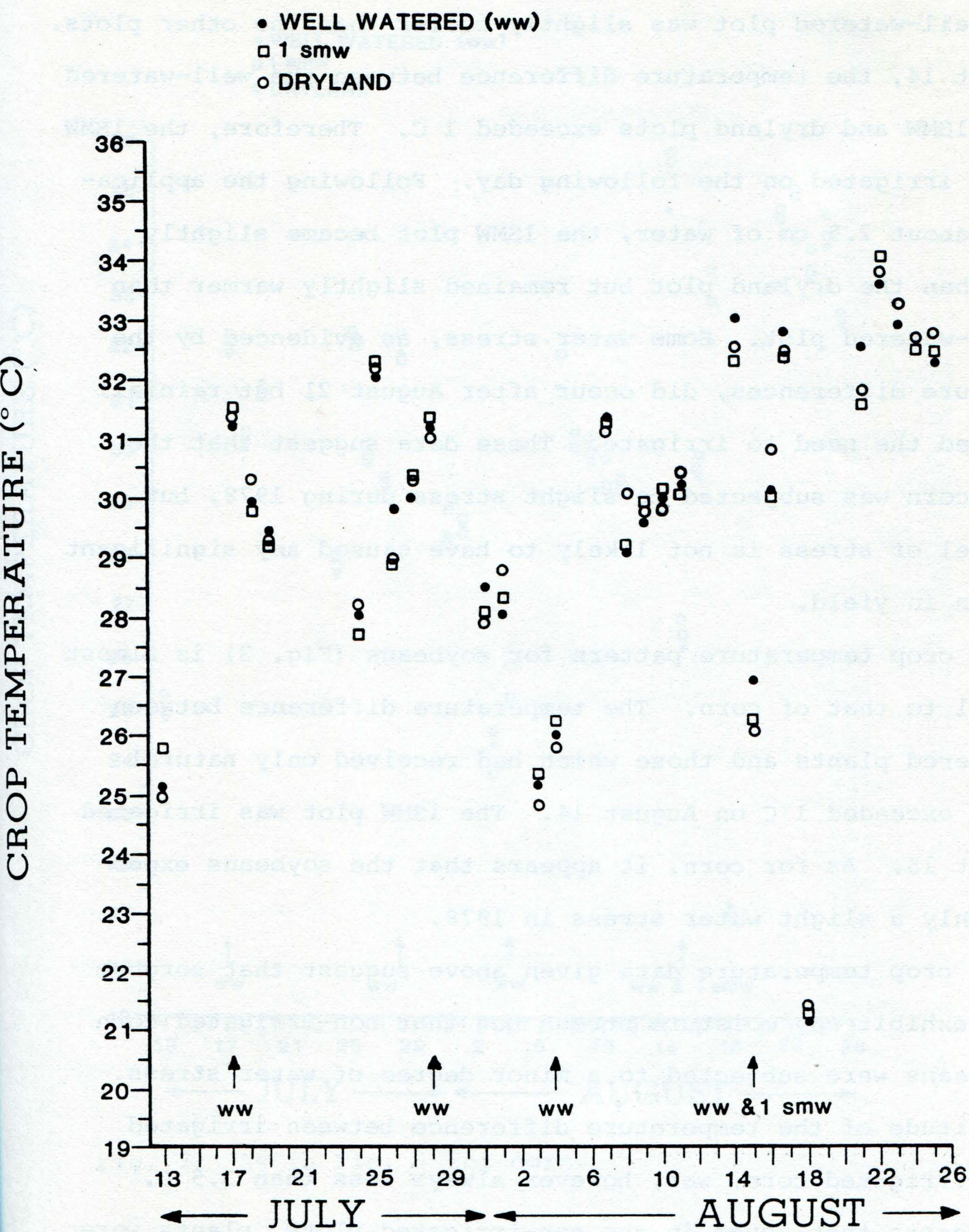

Fig. 1. Crop temperatures measured with an infrared thermometer for sorghum receiving different irrigation treatments. Dates of irrigation are indicated by the arrows. Data were obtained July 13 through August 25, 1978, at the University of Nebraska Mead Field Laboratory.

stress in sorghum at Mead.

There was no tendency before August 7 for the well-watered corn to be cooler than in the other plots (Fig. 2). After August 7, the well-watered plot was slightly cooler than the other plots. By August 14, the temperature difference between the well-watered and the 1SMW and dryland plots exceeded 1 C. Therefore, the 1SMW plot was irrigated on the following day. Following the application of about 2.5 cm of water, the 1SMW plot became slightly cooler than the dryland plot but remained slightly warmer than the well-watered plot. Some water stress, as evidenced by the temperature differences, did occur after August 21 but rainfall eliminated the need to irrigate. These data suggest that the dryland corn was subjected to slight stress during 1978, but this level of stress is not likely to have caused any significant reduction in yield.

The crop temperature pattern for soybeans (Fig. 3) is almost identical to that of corn. The temperature difference between well-watered plants and those which had received only natural rainfall exceeded 1 C on August 14. The 1SMW plot was irrigated on August 15. As for corn, it appears that the soybeans experienced only a slight water stress in 1978.

The crop temperature data given above suggest that sorghum did not exhibit any moisture stress but that non-irrigated corn and soybeans were subjected to a minor degree of water stress. The magnitude of the temperature difference between irrigated and non-irrigated corn, was, however always less than 1.5 C. This suggests that, even in the non-irrigated plots, plants were stressed only slightly. This degree of stress did not greatly

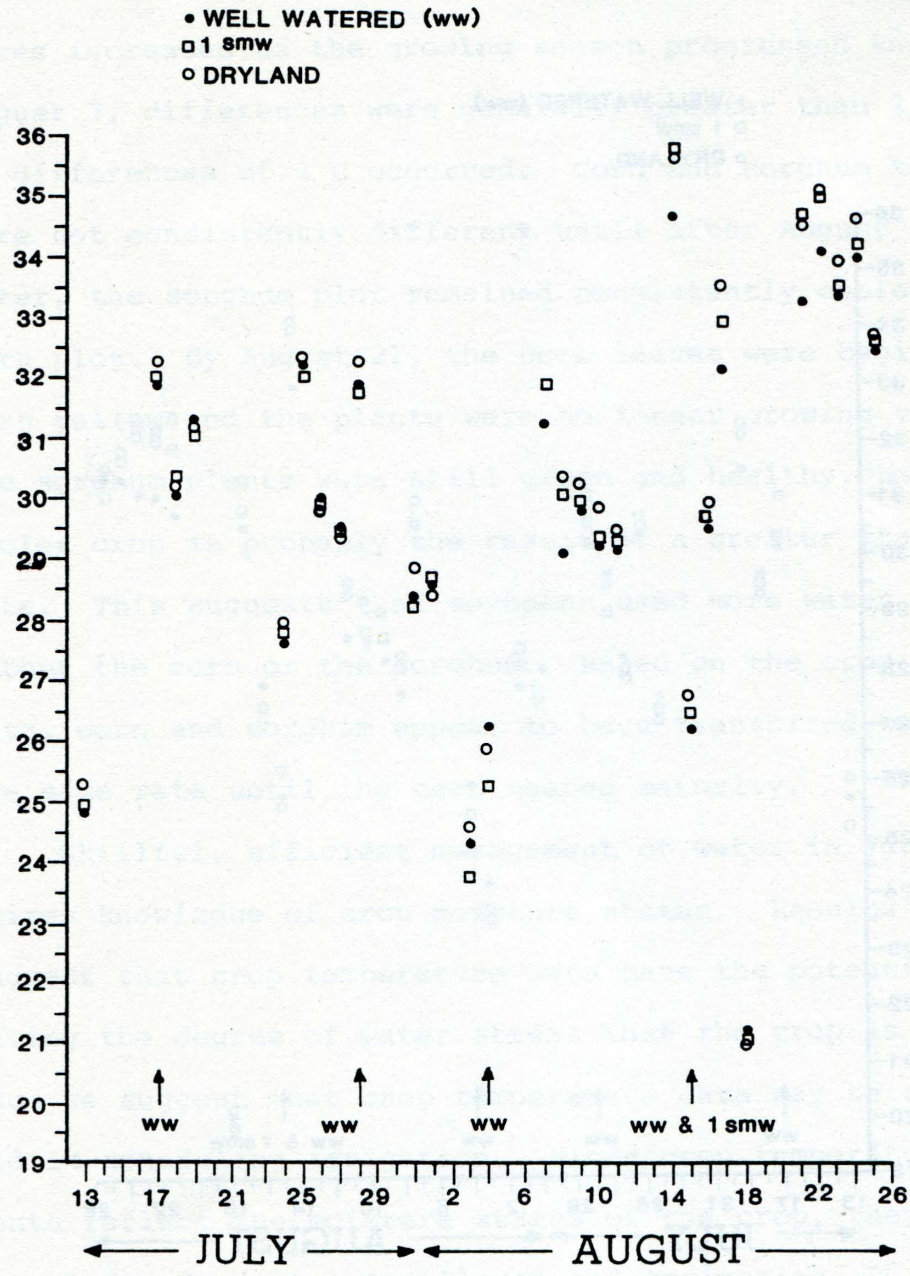

Fig. 2. As in Fig. 1 for corn.

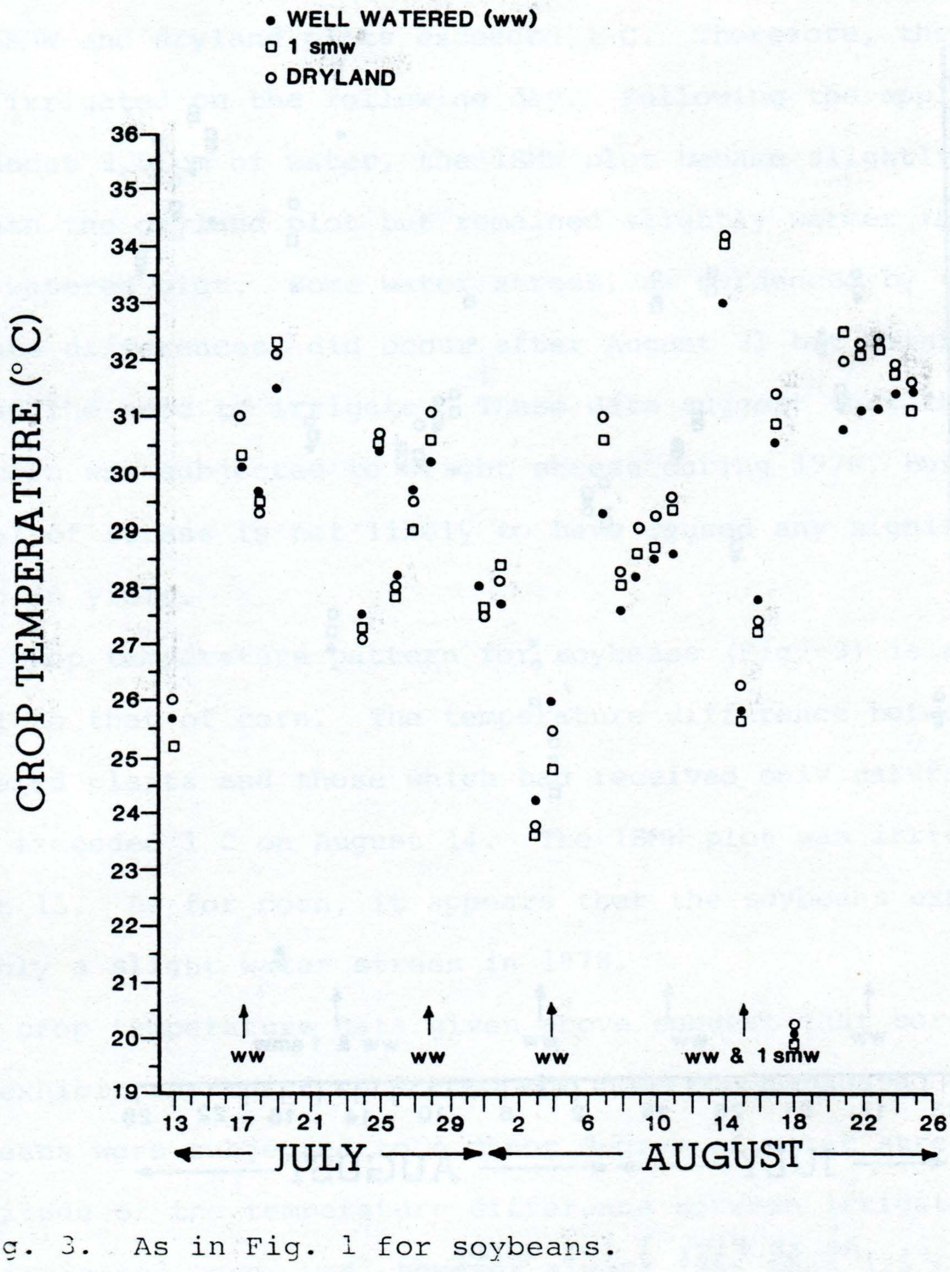

Fig. 3. As in Fig. 1 for soybeans.

reduce yields in the non-irrigated plots.

Crop temperatures of the fully-irrigated corn, sorghum and soybean plots are presented in Fig. 4. After July 24, the soybeans were always cooler than the corn and sorghum. The differences increased as the growing season progressed and, after August 7, differences were generally greater than 1 C. On August 22 differences of 3 C occurred. Corn and sorghum temperatures were not consistently different until after August 21. Thereafter, the sorghum plot remained consistently cooler than the corn plot. By August 21, the corn leaves were beginning to turn yellow and the plants were no longer growing vigorously. The sorghum plants were still green and healthy, however. A cooler crop is probably the result of a greater transpiration rate. This suggests that soybeans used more water than did either the corn or the sorghum. Based on the crop temperature data, corn and sorghum appear to have transpired water at about the same rate until the corn neared maturity.

Skillful, efficient management of water in agriculture requires knowledge of crop moisture status. Results of this study suggest that crop temperature data have the potential for indicating the degree of water stress that the crop is experiencing. Thus we suggest that crop temperature data may be used as an aid in scheduling irrigation. Since crop temperature measurements reflect the moisture status of the crop, they may provide a tool for drought surveillance and monitoring.

The results of this study show that various crops respond differently in their temperature response to moisture stress. Thus, it is unlikely that a general relationship between soil

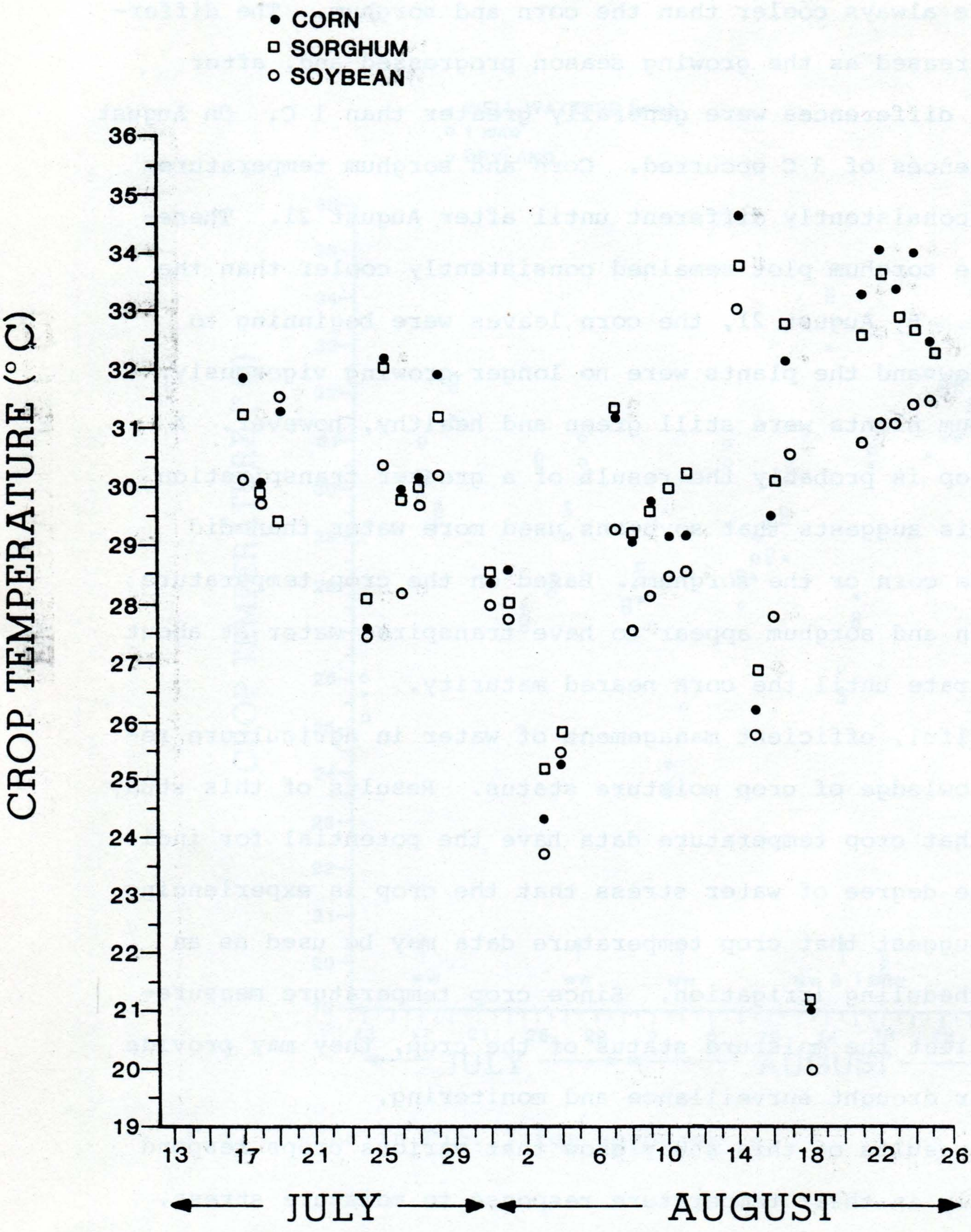

Fig. 4. Crop temperature patterns for the well-watered corn, sorghum and soybean plots during July 12 to August 25, 1980.

moisture and crop temperature can be applied to all agricultural crops but, rather, that the relationship for each crop must be studied separately. When such relationships are established crop temperature measurements may become a valuable aid in water resource management.

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